

The relation of the flora of the New Jersey Pine Barrens to the geological history of the region*

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The relation of the peculiar flora of the Pine Barren region of southern New Jersey to the geological formations of the region, and to the history of their origin and various modifications by submergence and erosion, has long been a subject of interest to botanists, ecologists and geologists. Some correlation between the remarkable and unusual plants found in the Pine Barrens within rather well defined limits, and the nature of the surface formations has been sought and a number of interpretations have been offered. The matter is still unsettled and a subject for amicable debate, but some of the probabilities which have been suggested by various authorities are here summarized.

The source of the material which makes up hundreds of feet of sand, with some pebbly and clayey layers in the more arid portions of the Barrens, was unquestionably in the highlands in northern New Jersey and eastern Pennsylvania. These strata are composed mostly of detritus from ancient pre-Cambrian rocks, the principal minerals of which in the order of their frequency, are quartz, feldspar, mica, magnetite, and hornblende. Detritus of all sizes was worn off these highlands, formerly much higher than now, and was carried by swift streams, probably following more or less the same valley lines as are now followed by the Schuylkill, Lehigh, Delaware, Musconetcong, the upper waters of the Raritan, the Passaic and Hackensack Rivers. With interruptions due to repeated submergences of the continental shelf sometimes extending far back to the highlands, the general course of erosion was to carry off the waste of the uplands and lay it down in shallow water on the ocean front, from the Raritan Bay to Cape May. More than a thousand feet of material was thus laid down to make what is now south Jersey. The marl, or greensand formations along the western and northern borders of the Barrens were laid down in shallow water swarming with marine life, at times cut off from the ocean, by the sandy islands then existing between the Delaware and the ocean, in a broad inland strait something like Long Island Sound of today.

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At the beginning of the long glacial period in the Pleistocene Epoch, the outlines of South Jersey and its elevation above sea level were probably very much like they are today. The ice did not reach South Jersey, for the terminal moraine extended from Perth Amboy, northwest over the Watchungs at Summit and westward to the Delaware at Belvidere. Some glacial material was carried down the southward trending valleys of the Raritan and Musconetcong, but it affected the composition of the soils of the Pine Barrens very little. It would not have changed them much, anyway, for the source of glacial material was the same as that of the detritus of the earlier stream erosion.

Of the mineral matter carried off the highlands into the ocean, or its arms as they may have existed from time to time in South Jersey, the quartz was the most resistant, and it makes up ninety per cent or more of the material of the Barrens today. The softer feldspar tended to break down into muds and clays. The magnetite was dissolved by vegetable acids and transformed into bog iron ore or clay iron stones. The other minerals left little trace. The Barrens therefore, when modern plants took possession of them in the Cretaceous Period, had a highly silicious soil, on which humus was slow in forming, except along the streams where more sustained moisture and plant decay provided narrow strips for a richer flora. Fires were probably frequent in the forests established thereon, from lightning, and have repeatedly burned over the area from long before the white man or the red man, although the former added much to the fire hazards, and still does so.

The advance of the ice in the Pleistocene may not have caused so much change in the flora of the Pine Barrens as might be imagined. The ice was approaching a line at which the warmth of the more southern latitudes balanced the cold which caused it, and this balance wavered, as shown by frequent retreats, some small, some great. The Barrens were thirty to seventy miles south of the greatest advance, and it is quite possible that most of the species held their ground. Some species which are usually regarded as northern ones driven south before the ice, like the Bearberry and Broom Crowberry probably migrated into the region at that time and one of the most interesting facts about the flora is that they still remain here.

After the white man came there was considerable disturb-

ance of original plant conditions by attempts at cultivation and the consequent introduction of adventive weeds, but so resistant have been the Barrens to wholesale modification by agriculture and horticulture, that large blocks of them retain their original and peculiar species.

Dr. Witmer Stone, in his monumental work on the Plants of Southern New Jersey, is unwilling to state any positive conclusions as to correlation of existing conditions of plant distribution in the Barrens with geologic changes. He thinks that hypotheses on this line are purely conjectural. He does point out these facts. The coastal plain, including what is now the Barrens, was submerged when the elevated Piedmont region to the west must have been covered with vegetation; and the region north of the terminal moraine, including most of the highlands of north Jersey, was almost wholly without plant life while it was covered by the ice sheets. The area between the coastal plain and the moraine, comprising some part of west Jersey and eastern Pennsylvania, must have been continuously covered with plants longer than the submerged plain and the glaciated region. When the coastal plain rose above sea it must have received its flora from the higher country to the west and southwest. The partial submergences and emergences of the coastal plain may have resulted in invasions of plants from outside and changes in the general character of the flora.

Dr. Stone points out that the plant life of the eastern United States includes two elements, a boreal, more or less identical with the flora of northern Europe, and an austral, peculiarly American. If the austral or American flora covered the Piedmont area at the time the coastal plain was elevated, it would have spread into the new territory, and the species best adapted to the sandy, dry Barrens, would have persisted there. If an invasion of the boreal species over the Piedmont area followed, from the southward migration forced by the advancing ice, "we should probably have," he says, "exactly the conditions we find today, the survival of an earlier flora in the bogs and sandy areas and its disappearance where better soil has developed," in the western part of the State, where later submergence in Pensauken time and formation of alluvial deposits by the Delaware, made a richer soil and perhaps led to the destruction of the Pine Barren elements and confined them to the arid interior of South

Jersey. Dr. Stone concludes that "it would seem, therefore, that we have in the New Jersey and North Carolina Pine Barrens the sand and bog elements of a wide-spread American austral flora, which has been largely superseded by a more advanced element of similar origin over the rest of the coastal plain, both elements being richer the farther south we go, while along the western edge of the coastal plain, more especially to the northward, a boreal element has spread down over the fall line to a greater or less degree."

But Norman Taylor, in his "Flora of the Vicinity of New York," expresses his firm conviction that a geological explanation of the character of the plants in the Pine Barrens is the only one that will elucidate the peculiarly local nature of the flora.

He quotes Dr. Arthur Hollick and Dr. J. W. Harshberger in partial support of his belief. He refers to the Miocene sinking, when great quantities of material washed off the highlands were laid down to form the Beacon Hill formation, now found capping the higher parts of the Barrens. After uplift and erosion, the region was again submerged in Pensauken time, so that everything but the remnants of the Beacon Hill formation was under water. He stresses the point that this Beacon Hill formation has been out of water since upper Miocene time, and several times partly or entirely surrounded by the sea, making a large island extending from Farmingdale to Bridgeton, with smaller islands northward, including Atlantic Highlands and Beacon Hill. This Beacon Hill formation was the oldest in southern New Jersey that could have been continuously covered with vegetation. "This, it would seem," he says, "is why the Beacon Hill formation is the controlling factor in the origin and present distribution of the Pine Barrens. The area of the pine-barrens is not exactly coextensive with Beacon Hill but the differences are so slight that recent and local erosion of the formation would account for the failure of the two regions to superimpose, as it were."

He concludes, therefore, that the "New Jersey pine-barrens exist exclusively on this Beacon Hill formation, an area isolated by geological processes, and maintaining a relict or climax flora, the antiquity of which greatly antedates any of the rest of our vegetation hereabouts, so far as permanency of position and phytogeographical isolation are concerned."

This flora was modified by the effect of the last great glaciation which drove many northern species southward into this Beacon Hill or pine-barren area, in which some still persist, notably the Bearberry and Broom Crowberry.

Another interesting explanation of the character of the pine-barren flora is suggested by Professor M. L. Fernald of Harvard, in an article in *Rhodora*, the journal of the New England Botanical Club, for February, 1931, entitled "Specific Segregations and Identities in Some Floras of Eastern North America and the Old World." By means of paleogeographic maps, after Schuchert, Professor Fernald shows land connections between North America and northern Europe and Asia, which may account for the likenesses in many plants common to these continents. He points out the occurrence in the high mountains of eastern Tennessee of a number of species also found in the New Jersey pine-barrens. He supposes that these species were once numerous in east Tennessee when the region was a low, nearly base-levelled peneplane, in the Cretaceous Period. When it was later uplifted, species from the north, deriving from northern Europe and northern Asia, moved south, into the new highlands and the members of the groups of tropical and sub-tropical forms, once contented in the peneplaned lowland, were forced out into conditions more to their liking in the emerging coastal plain where acid savannahs, bogs, shallow pools and dry sands supplied the conditions which permitted them to survive. The occurrences of what we regard as typically pine-barren species in the Great Smokies are therefore probably dying remnants of a much larger distribution, migrants from which spread eastward and downward to conditions like those which existed in East Tennessee before the post-Cretaceous uplift.

These interesting attempts to interpret our pine-barren flora probably all have some measure of truth, but their authors would doubtless admit that they may have to be changed by later discoveries. That botanists of note may differ is indicated in Dr. Stone's footnote on *Corema*, Professor Fernald regarding it as a Coastal Plain plant pushing north to Newfoundland, while Dr. Stone had always looked upon it as a northern species ranging south to New Jersey.

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